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Title of the Invention

METHOD AND APPARATUS FOR RECONDITIONING COMPACT DISCS

Cross-Reference to Related Applications

This a divisional of U.S. Application Serial No. 09/449,153, filed November 24, 1999, which is a continuation-in-part of U.S. Application Serial No. 08/879,711 filed June 20, 1997, both entitled "Method And Apparatus For Reconditioning Compact Discs."

Field of the Invention

The present invention relates to compact discs and more particularly relates to an apparatus and method of reconditioning both audio and compact discs by removing scratches and blemishes in the protective plastic layer on one side of the disc which occur through use and handling of the discs.

Background of the Invention

Compact discs (CD's) are widely used for storing both audio and visual information in digital form. Compact discs are discs which consist of a disc of plastic having a thickness of about 1 mm to 1.5 mm and typically have a diameter of about 4-3/4 inches. Other types of

discs such as digital videodiscs (DVD's) have a smaller digital information band. The information, in digital form, is recorded on an information layer which consists of a continuous spiral data track. After the data is placed on the disc, a metallic film is placed over the data and it is sealed with a protective layer. Damage to the information layer can occur if scratches or other surface blemishes occur in the plastic protective layer. CD's generally have a data track on one side while some discs, such as DVDs, store data on both sides.

Reading of discs is accomplished by a laser beam which scans the disc through the plastic protective layer. The laser is reflected by the metallic film. Damage, as mentioned, to the protective layer will interfere with the scanning process such that tracking errors or distortion will occur when the disc is played.

Even relatively small scratches or blemishes resulting from handling of the disc can lead to disturbances in faulty reproduction. The laser reading beam scans the data track and blemishes, imperfections and scratches in the protective layer which is generally a polycarbonate, will hinder the laser's ability to properly read the data and "skips" will occur.

The prior art discloses various methods and apparatus for refinishing CD's.

U.S. Patent No. 5,220,754 shows a method for restoring compact discs in which the disc is held and a scraping action is applied to the coating on the disc.

U.S. Patent No. 5,571,041 discloses a method for repairing and refinishing audio and video CD's. The top side of the disc is placed against a soft, covered wheel and secured to the wheel. The disc is spun on low rpm and a heavy cut cleaner applied across the surface of the bottom side of the disc using a clean cotton cloth or pad. This step is repeated at higher rpm

using a medium cut cleaner and then a finer cut cleaner. Clear plastic cleaner and a clear plastic polish are then applied using a cotton pad.

U.S. Patent No. 5,207,759 discloses a method for texturing a disc using a slurry. The slurry includes different sized particles, preferably a first in the 3 micron size range and a second in the 1 micron size range. Particles are used to abrade the surface of the disc. A pad is moved relative to the disc to scour the substrate.

U.S. Patent No. 5,167,096 discloses a method and apparatus for texturing a substrate. A texturing pad and the disc are rotated about parallel, offset axis and pressed against one another in the presence of a particle slurry. The inner, less compressible region of the pad produces a deeper grooved texturing on an inner, annular surface of the disc.

U.S. Patent No. 5,099,618 discloses a method for repairing damaged recording discs by removing a part of the protective layer in directions cutting across the data track path.

U.S. Patent No. 4,179,852 relates to a method and apparatus for polishing a floppy disc. The floppy disc is placed on a circular, resilient pad disposed on a first spindle-mounted circular platen. A circular, fibrous or abrasive polishing disc is disposed on a second spindle-mounted circular platen. The radius of the polishing disc is greater than the width of an annular region to be polished on the disc so that the relative velocities between points on the polishing disc and the points on the floppy disc are uniform. In the apparatus of this patent, the floppy disc and polishing disc are rotated in the same angular direction at first and second velocities.

Summary of the Invention

The present invention relates to a method and apparatus for reconditioning compact discs by removing blemishes or scratches in the polycarbonate or plastic protective layer by a multiple step process in which the discs are first resurfaced and then subsequently polished to their original factory condition.

Re-surfacing is first accomplished in an apparatus having a cabinet in which is mounted a pair of motors having spindles or shafts vertically extending in spaced parallel relationship. The spindles or shafts are rotated in opposite directions, one being rotated clockwise and the other being rotated counter-clockwise. The shafts extend upwardly into a re-surfacing chamber in the cabinet. Each of the shafts extend through a fixed protective sleeve. An arbor is secured to the end of one of the shafts and a resilient foam pad is detachably secured to the arbor by an adhesive or a loop and hook fastener material such as that sold under the trademark Velcro®. A circular pad having an abrasive surface is secured to the upper surface of the foam pad with the abrasive surface facing upwardly. The adjacent, oppositely rotating shaft has a protective sleeve about it and has a threaded upper end. A collar and hub are adjustable and secured to the shaft. The disc to be processed is placed on the collar and a locking knob may be tightened about the threaded distal end of the shaft to secure the disc in place for processing. The collar may be axially adjusted on the shaft to insure that the disc and the abrasive surface are parallel and in full light engagement. A plate-like bearing member may be interposed between the locking knob and the disc. When the disc is positioned for re-surfacing, the plastic protective layer on the underside of the disc

overlaps the abrasive material on the pad on the adjacent shaft. The diameter of the arbor and associated abrasive disc are selected so that the abrasive disc does not overlap the annular data track or mirror band the center of the disc being processed.

A water reservoir is provided in the cabinet of the re-surfacing machine and water or other fluid is discharged onto the upper surface of the abrasive material in a wet sanding operation. The motors when energized rotate at a predetermined speed and re-surfacing progresses until the deeper scratches are removed. Abrasive materials having different grits, as for example 30 micron, 15 micron, 9 micron and 3 micron particle size grit, may be progressively used to remove scratches by removing a portion of the plastic protective layer. The water and any removed material is collected in a sump in the bottom of the re-surfacing chamber and discharged to a collection area or drain.

Once re-surfacing has occurred, the discs are subjected to a second process which is a polishing process to smooth the protective plastic surface of the disc to its original condition. This is accomplished in an apparatus also having a cabinet containing a pair of spaced-apart motors with vertically extending shafts. The polishing machine is constructed similar to the re-surfacing apparatus described above, having an arbor on one motor shaft which rotates in one direction. A foam pad is detachably securable to the arbor. The compact disc to be processed is mounted on the adjacent shaft at a collar overlapping the foam pad. A locking knob and bearing plate secure the CD in place. The locking knob is in threaded engagement with threads on the upper or distal end of the rotating shaft. Generally, an abrasive material is not utilized in the polishing operation. Instead, a polishing compound, preferably a water-

based compound, is applied to the upper surface of a foam polishing pad when the motors are energized, polishing continuing until the protective surface of the compact disc is restored to its original condition.

The re-surfacing and polishing operation may be carried out in a single device incorporating the apparatus described above. Also, multiple work stations may be provided in both the re-surfacing and polishing apparatus.

Brief Description of the Drawings

The above and other objects and advantages of the present invention will be more apparent from the following description, claims and drawings in which:

Figure 1 is a perspective view, partly broken away, of the re-surfacing apparatus according to the present invention;

Figure 2 is a cross-sectional view of the re-surfacing machine shown in Figure 1;

Figure 3 is a sectional view taken along line 3-3 of Figure 2;

Figure 4 is a schematic of the electrical system of the re-surfacing apparatus of Figure 1;

Figure 5 is a detail perspective view showing the end of the motor shaft and the mounting for receiving a compact disc to be polished;

Figure 6 is a detail perspective view of the end of the motor shaft of the re-surfacing machine which receives the polishing material;

Figure 7 is a perspective view of the polishing apparatus for performing the polishing operation according to the present invention; and

Figure 8 is a cross-sectional view showing the motor chamber of the polishing machine of Figure 7.

Detailed Description of the Invention

The present invention provides both an apparatus and method for re-conditioning compact discs and other discs containing digital information such as DVD's and game discs. The method involves first removing the deeper scratches and blemishes in a first re-surfacing apparatus of the type shown in Figures 1 to 4. Subsequently, the plastic surface of the discs, from which the deeper blemishes and scratches have been removed, are polished on a polishing apparatus such as shown in Figures 7 and 8. Both the apparatus of Figures 1 to 4 and the apparatus of Figures 7 and 8 utilize a first rotatable shaft on which the CD to be processed is mounted and a second, spaced-apart parallel shaft which has an arbor on which the polishing pad or abrasive material is mounted. The two shafts are rotated in opposite directions toward one another at approximately the same rotational speed. The compact disc overlaps a portion of the polishing pad or abrasive material on the adjacent shaft. The term "Compact Disc" or "CD" as used herein is intended to encompass various types of digital recording discs such as compact discs, digital video discs, game discs and compact disc recordables and similar discs on which digital information is embedded.

Turning now to Figures 1 to 4, the re-surfacing apparatus of the present invention is shown and is generally designated by the numeral 10. The re-surfacing apparatus has a cabinet 11 with a front wall 12, opposite side walls 14 and 16, bottom 18 and a rear wall 20. The cabinet is open at its upper end but has a planar floor 22 which is parallel to the bottom and is spaced downwardly from the upper edge of the cabinet. The floor 22 divides the cabinet into a lower component chamber 26 which receives the motor and other components of the apparatus and an upper re-surfacing chamber 30. An optional drawer 32 may be slidably received within the front wall 12 for storage of materials such as abrasive pads and the like. Handles may be provided for convenience when lifting or moving the apparatus.

The component chamber houses a reservoir 34 which may be any convenient shape but is shown as a generally rectangular structure positioned immediately adjacent the front wall 12. The reservoir 34 is preferably fabricated from a transparent material such as plastic. The front wall 12 defines a vertically extending, elongated aperture 38 which serves as a sight glass so that the level of the liquid in the adjacent reservoir 34 can be visually observed by the operator.

A submersible pump 40 is positioned in the reservoir and has an outlet connected to a flexible tubing section 42 which terminates at a fitting 46 in floor 22. A vertical supply tube 48 is, at its lower end, secured to fitting 46. At the upper end of supply tube 48, a manually controlled valve 50 is positioned which has a flexible outlet or nozzle 52. Reservoir 34 has an inlet 54 which is connected to a suitable source of fluid so that it may be filled to a desired

level when it is observed that the level is below a predetermined level, such as the fill level "F" as indicated in Figure 1.

Opposite end walls 14 and 16 are provided with a series of vents or louvers 54. A first fan 60 is located against end wall 14 and draws air from the exterior of the cabinet and discharges it into the component chamber. A second fan 61 is located against the interior side of end wall 16 and draws air from within the component chamber and discharges it through the louvers 54 in end wall 16. The fans operate to keep the components within the component chamber cool.

Polishing is accomplished by means of motors M1 and M2 which are electric motors preferably fractional horse power motors operable between approximately 700 rpm and 1,750 rpm. The motors may be either fixed or variable speed. The motors rotate in opposite directions toward one another and M1 is shown as operating in a counter-clockwise direction and M2 operating in a clockwise direction. The motors, fans and pump are in a circuit as shown in Figure 4 and are energized by power switch "S" and timer "T". Motor M1 has an output shaft 62 which extends upwardly into the re-surfacing chamber 30. The shaft 62 is housed within a fixed sleeve 64 which extends upwardly from floor 22. The upper or distal end of shaft 62 is threaded at 65 as best seen in Figure 5. A hub 66 is slidable along the shaft and has an annular collar 68 at its upper edge. A set screw 69 is provided so that the collar and hub may be positioned at any selected axial position along the shaft 62. A locking knob 68 has an internally threaded portion 70 which is selectively engageable with threads 65.

As seen in Figure 5, it will be seen that a CD to be processed may be positioned over the end of the shaft 65 with the center opening in the CD aligned with the end of the shaft. The CD will rest on the collar 68 of the hub. A bearing plate 75 is preferably interposed between the locking knob and the upper surface of the CD to apply uniform pressure over the surface of the CD. When the re-surfacing operations are carried out, the CD is positioned with the label area disposed upwardly and the plastic protective layer which is to be re-conditioned, disposed downwardly.

Motor M2 is provided with vertically extending shaft 82 which is in spaced parallel relationship with shaft 62. Shaft 82 also extends through a fixed sleeve 84 which projects from the upper surface of floor 22. The upper end of shaft 84 carries an arbor 88 which is mounted on a hub 86 as seen in Figures 2 and 6. Hub 86 is securable to shaft 82 by means of set screw 89. The diameter of the arbor and abrasive are selected having diameters corresponding to the radial width of the data track on the disc to be processed. If a disc, DVD, is to be processed, the arbor 88 may be replaced with an arbor selected having a diameter that does not overlap into the center or mirror band of the disc. This band may contain information which if scratched may prevent the disc from loading or may remove the title. For example DVD and Sega Dream Cast® have information bands that have a width different than compact discs.

The upper surface of arbor 88 may be provided with areas of a suitable fastener material 90 such as one component of a loop and hook fastener or adhesive patches. The diameter of the arbor is selected so that the arbor will overlap the CD being processed to

approximately the label area of the CD when the CD is positioned on collar 68. The arbor supports the re-surfacing or polishing components. It will be noted that Figures 5 and 6 are representative of the shaft mounting for both the re-surfacing apparatus described in Figure 1 and the polishing apparatus shown in Figure 7 and described hereafter. The principal difference is that the re-surfacing operation utilizes a resilient pad 91 which is detachably secured to the upper surface of the arbor 88 and held in place by the strips of fastening material 90. The foam pad is a resilient expanded foam and provides a smooth re-surfacing and polishing operation. The pad also is used without an abrasive in the subsequent polishing operation. A suitable pad is one sold by Crain Industries of Phoenix, Arizona. In the re-surfacing operation, an abrasive disc 100 is placed on the upper surface of the foam pad 91. The pad 91 provides resilience so that excessive material removal does not occur from the bottom surface of the CD. Preferably, in the re-surfacing operation, various grits of abrasive material are used generally starting with 30 micron and decreasing to 3 micron in selected, progressive steps. In the polishing operation, polishing is accomplished by using upper surface of the foam pad 91 without an adhesive material and in place of the adhesive material a polishing compound is applied to the pad.

The re-surfacing apparatus shown in Figure 1 further includes a protective cover 150. The protective cover is preferably fabricated from a transparent material and has front wall 152, rear wall 154 and opposite end walls 156, 158. The walls form a rectangular box-like structure which is slidably received within the open upper end of the cabinet. The lower end of the walls of the cover rests on the floor 22. Thus, the entire protective covering can be

removed for cleaning when necessary. A lid 160 is hinged to the rear wall 154 and extends across the top of the transparent cover. The lid can be opened to provide access to the re-surfacing chamber.

Referring now to Figures 7 to 8, the polishing apparatus is shown. As mentioned above, the polishing apparatus is similar to the re-surface apparatus and utilizes motors M1 and M2 as described with reference to the re-surfacing apparatus of Figure 1. Further, the mounting for the CD at the upper end of motor M1 of the polishing apparatus is essentially the same as that has been described with reference to Figure 5. Motor M2 supports a vertically extending shaft which supports an arbor 88 to which a polishing pad 91 can be detachably secured.

The polishing apparatus of Figures 7 and 8 is generally designated by the numeral 200 and has a cabinet 211 with front wall 212, opposite end walls 214, 216 and rear wall 220. The upper end of the cabinet is open and the floor 222 extends horizontally at an elevation below the upper edges of the cabinet. The floor 222 divides the cabinet into a lower component chamber and an upper polishing chamber. Motors M1 and M2 are contained in the lower component chamber along with fans 260 and 261 located on the interior of end walls 214 and 216, respectively. Louvers 254 are provided in the opposite end walls so that a flow of cooling air is induced through the lower component chamber. A suitable timer "T" may be set to a desired time. The schematic in Figure 4 is representative of the circuitry of the electrical components of both Figures 1 and 7.

The polishing apparatus 200 is provided with a protective cover 260 which is, again, shown as being transparent having front, rear and opposite side walls defining a generally rectangular structure. A lid 250 is hinged to the rear wall so that access to the polishing chamber is accommodated. Further, the protective cover 260 rests on the floor 222 so that the entire cover may be removed for cleaning or servicing as necessary.

In use, the CD to be processed is first subjected to re-surfacing in the apparatus shown in Figure 1 to 5. As seen in Figure 5, the CD is mounted on the shaft of section M1 with the label area disposed upwardly and the protective plastic layer disposed downwardly. The CD is positioned on the collar 68 of hub 66 and the hub positioned at an elevation so that the plastic layer will be in gentle but firm flat-to-flat contact with the abrasive material 100 disposed on the upper surface of the foam pad 91. The diameter of the arbor 88 and the abrasive disc 100 are selected so as to fully re-surface the annular digital information bearing area "A" without damaging the center band "B". Re-surfacing and polishing occurs from the peripheral edge of the disc to the band "B" although the information band may not extend entirely to the peripheral edge. The flat-to-flat procedure also avoids rounding the edges of the disc. Bearing plate 75 is positioned over the label area of the CD and the knob 68 is tightened in place. The bearing plate is circular, preferably plastic, having an anti-slip coating 76 which maintains the disc firmly in a planar position and resists slippage of the disc during processing. The foam pad is detachably secured to the upper surface of arbor 88 and supports adhesive material 100. The timer "T" is set to the desired time, as for example from one to several minutes, depending upon the severity of the scratches and blemishes on the CD. The

motors, pump and fan are energized by the power switch "S" which causes motors M1 and M2 to rotate in opposition directions inwardly toward the polishing area 1 as shown in Figure 3.

Water is delivered to the upper surface of the abrasive medium to provide a wet sanding operation and to keep the disc cool. Re-surfacing continues for a period of time until at least the more severe blemishes and scratches are removed. The operator will then determine whether to continue re-surfacing using abrasives of a finer grit, as for example 15 micron abrasive material. To do this, the abrasive material 100 can simply be peeled off the upper surface of the disc and another adhesive layer placed on the upper surface of the foam pad. Preferably the abrasive material has a backing with a lightly pressure sensitive adhesive which will maintain the abrasive material on the foam pad. During the re-surfacing operation, the transparent covers allow full visual inspection but provides protection to the operator and prevents splattering.

Alternately, the operator may determine to process a number of CD's and in doing so may subject a group of CD's to the initial abrasive re-surfacing operation using more abrasive material. Once a number of CD's have been subjected to re-surfacing using an abrasive material, for example 30 micron abrasive, progressive re-surfacing using finer abrasives can be performed.

Once re-surfacing operation has been completed, the discs are then subjected to final polishing in a polishing apparatus such as that shown in Figures 7 and 8. The CD is mounted on the shaft of motor M1 in the manner shown in Figure 5 and motor M2 supports an arbor and foam polishing pad having a selected diameter to polish the annular information area. If

the disc does not gently, firmly and fully contact the polishing pad, the hub and collar 66 can be loosened at set screw 69 and axially adjusted along shaft 62 to achieve proper alignment and contact. The flat surface-to-surface polishing and re-surfacing restores the discs without damage to either the information layer or the center band and avoids rounding of the edges which can irreparably damage a disc. No abrasive is used in the polishing operation. Neither is water necessary. The motors are energized and a suitable polishing compound such as that available from Ultra Tech Manufacturing Co. of Bloomington, Minnesota is applied to the upper surface of the foam pad 91. Polishing will restore the surface of the disc to its original factory condition. When polishing is completed, the disc is removed by loosening knob 68 and the CD can be subjected to final cleaning and is ready for use.

While the above apparatus and method has been described with respect to separate re-surfacing and polishing machines, it will be obvious that re-surfacing and polishing machines can be housed within a single cabinet. It will also be apparent to those skilled in the art that re-surfacing and polishing machine as described above may be constructed having a plurality of re-surfacing and polish work stations within a single cabinet. In such a configuration, multiple pairs of motors M1 and M2 would be provided within the single cabinet. Re-surfacing abrasive material suitable for this purpose having various grits, such as those of the type manufactured by PSI Testing Systems, Inc.

While the principles of the invention have been made clear in the illustrative embodiments set forth above, it will be obvious to those skilled in the art to make various modifications to the structure, arrangement, proportion, elements, materials and components

used in the practice of the invention. To the extent that these various modifications do not depart from the spirit and scope of the appended claims, they are intended to be encompassed therein.

I CLAIM: